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WESTERN SPRUCE BUDWORM FEEDING EFFECTS ON CONIFERS LOCATED ON THE BOISE AND PAYETTE NATIONAL FORESTS

by

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ABSTRACT

During 1981 and 1982, 85 stands stocked predominantly with grand fir or Douglas-fir were surveyed on the Boise and Payette National Forests, to evaluate effects of western spruce budworm feeding in coniferous stands. Tree data were backdated to predefoliation status then projected through the defoliation period by the stand prognosis model utilizing radial growth data from pre-defoliation and defoliation growth periods. Difference in values for these projections estimated the budworm effect on radial growth of true firs to be a reduction of 30-40 percent. Douglas-fir and spruce demonstrated a 15 percent reduction in radial growth while ponderosa pine and, in some areas, lodgepole pine experienced a slight increase in growth. Top kill was common on true firs affecting 10-20 percent of sampled trees; mortality, however was infrequent.

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INTRODUCTION

Conifer defoliation by western spruce budworm (Choristoneura occidentalis, Freeman) on the Payette National Forest in southwestern Idaho during 1968 has proven to be the vanguard of an outbreak which has persisted over much of the Boise and Payette National Forests for more than a decade (Knopf, 1968). Evaluations of budworm effects on volume production in commercial stands on these forests were initiated in 1976 (Ollieu, 1976, 1977; Beveridge, 1978). However, data collected had certain limitations and consequently new evaluations using an improved survey design and analytical techniques were initiated. Instrumental in these improvements were: Mike Marsden, Biometrician, Forest Pest Management, Methods Application Group; Bill Wycoff, Mensurationist, Intermountain Forest and Range Experiment Station; Nick Crookston, Research Associate, College of Forestry, University of Idaho, Canada/U.S. Spruce Budworm Program-West; and Ralph Johnson, Multi-Regional Forest Management Systems Specialist, Cooperative Forestry and Pest Management.

METHODS

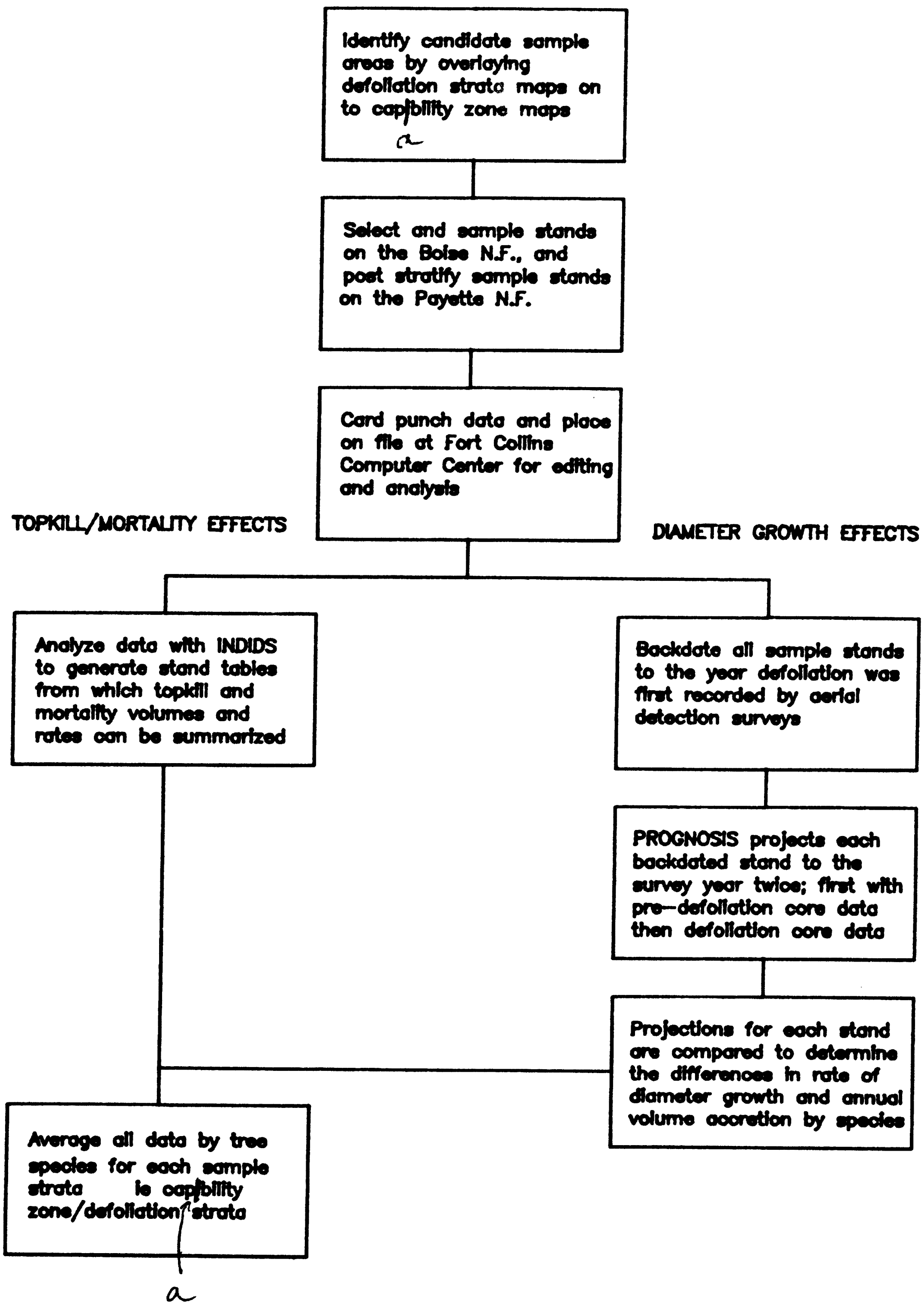
Field data were collected from stands located on the Payette and Boise National Forests during 1981 and 1982 respectively. Initial stand selection varied by forest, but survey design and sample methods within stands were consistent.

A schematic flow of processes and methods used to determine effects of budworm feeding on conifers is displayed in Figure 1.

Sample stand selection on the Payette National Forest was based primarily on presence of defoliation, stand size, and stand accessibility. On the Boise National Forest, in addition to these criteria, land base and defoliation stratifications were used to select sample stands. The land base stratification, accomplished by forest personnel, divided the forest land base into 22 different zones having similar climatic and geologic characteristics (Appendix A). These zones are referred to as forplan or capability zones (CZs)

FIGURE 1

SCHEMATIC FOR ANALYSIS OF WESTERN SPRUCE BUDWORM SURVEY DATA



and were prioritized for sampling. Highest priority CZs were those known or anticipated to be of highest value in terms of wood volume production and known to have largest acreages of defoliated conifers. Generally, these were units forested predominantly with grand fir.

Areas within the general outbreak area were grouped into four defoliation strata. These groupings were based on total years of aerially detected defoliation during the current outbreak (1968-1983) and were: no visible defoliation; 1-3 years; 4-6 years; and 7 or more years of visible defoliation (Figure 2).

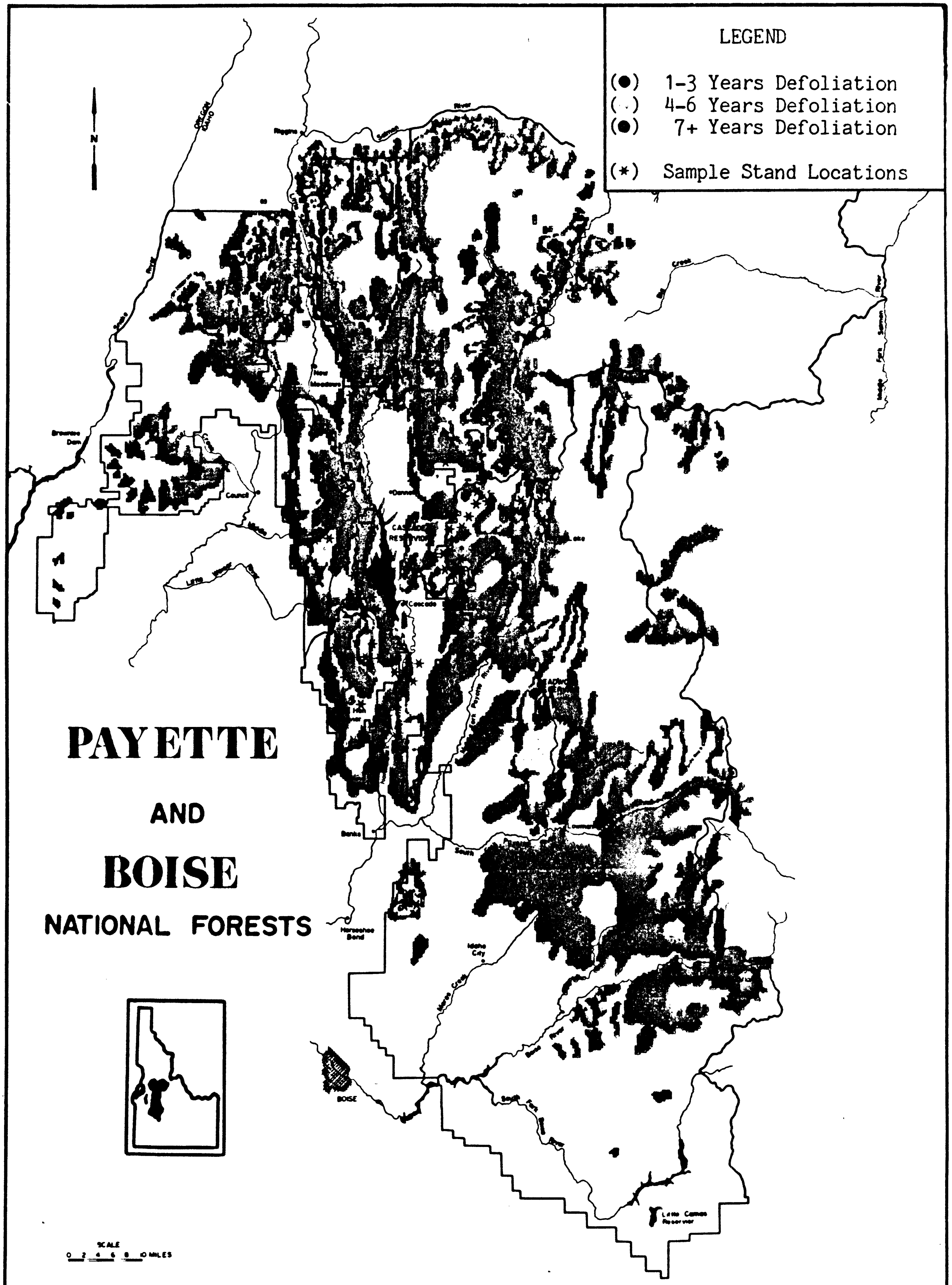
The project design was to sample each defoliation stratum that occurred in each of the high priority CZs. To accomplish this, defoliation strata maps were prepared using aerial survey information and were overlayed onto CZ maps to identify candidate sample areas in each defoliation stratum/CZ category. Stands in each grouping having reasonable access and being 10-100 acres in size were then identified for sampling. At least three stands in each defoliation stratum of the high priority CZs were to be sampled.

Once sample stands were identified, stand boundaries were delineated on color resource photographs. These were used to help locate sample stands on the ground and to orient sample points.

Land base and defoliation stratifications were not used to select sample stands on the Payette NF. However, to enable usage of the data in these evaluations, sampled stands were post stratified according to CZ and defoliation stratum descriptions for the Boise National Forest.

In each selected sample stand, data collection points were established on a 5 x 10 chain grid. At each point data were collected from both a variable and a 1/300 acre fixed plot. All trees with a diameter of five inches and greater at breast height (DBH) were sampled in the variable plot, while in the fixed plot trees less than five inches DBH were sampled. On both plots: species, DBH, crown ratio, crown class, and presence of insects or diseases were recorded for each sample tree. The percent of crown defoliated by budworm was estimated and length of top-kill measured for each host tree encountered.

FIGURE 2
Cumulative Years of Budworm Defoliation and Sample Stand Locations



On each variable plot total tree height was measured and one increment core was extracted at DBH from the first four live trees encountered. Tree age was determined from core examination for the first tree encountered on each plot. All four cores were placed into plastic straws, labeled, and returned to the laboratory where annual ring width (radial growth) for varying periods was measured with the aid of a dissecting microscope.

At least three growth measurements were obtained from each core. These were: (1) radial growth during the defoliation period, i.e., defoliation growth; (2) radial growth during the ten year period immediately prior to initial observation of defoliation, i.e., pre-defoliation or nondefoliated growth, and (3) radial growth during the ten years preceding the survey. Aerial detection survey maps were used to determine when defoliation was first observed in each stand sampled.

On each fixed plot, height growth for the previous five years was measured for the first two trees.

General site information such as habitat type, percent slope, elevation, and aspect was determined and recorded for each stand.

All data were edited, placed on file at the Fort Collins Computer Center, and analyzed by a variety of methods. First, the "INDIDS" computer program (Bousfield, 1980) was used to produce a series of tables from which incidence of budworm-caused top-kill and mortality was summarized. Additionally, the program was used to calculate volume losses associated with mortality and reduced accretion due to top-kill and to generate basal area information for each conifer species in each stand.

These summaries plus increment core data were then used in the stand prognosis model (Wycoff, 1982) to estimate the direct effects of budworm feeding on hosts and the indirect effects on nonhosts in stands sampled in the various capability zone/defoliation strata.

Core measurements from trees defoliated during the current outbreak were used

to estimate growth during defoliation, and core measurements from pre-defoliation growth were used to estimate growth without defoliation. Tree data were backdated to pre-defoliation conditions, then utilizing growth rates calculated from the two radial increment core measurments, each sample stand was projected by the stand prognosis model to the survey year. Differences in the projected values were then summarized to yield effects on tree growth.

RESULTS

Eighty-five stands from six different capability zones were sampled: 38 on the Payette National Forest and 47 on the Boise National Forest (Fig. 2). Numbers and characteristics of stands sampled in each CZ are listed in Table 1. Capability Zone 14 was by far the most intensively sampled zone, followed by CZs 13, 15, 9, 21 and 5.

Data pertaining to incidence of top-kill by conifer species and size class are summarized in Table 2. Frequency of top-kill and range of values are presented in Table 3. Average radial growth changes, top-kill and mortality, plus associated volume increases or decreases are listed by defoliation strata for each CZ in Table 4. All volume loss data, top-kill, or radial increment loss are averaged from all sample stands in a given category.

Because effects of budworm feeding on individual tree species and in various CZs are important in assessing management alternatives, the above data will be summarized and presented under those two groupings. Data presented pertain to the current infestation sampled, not to a simulated infestation.

Effects of Defoliation on Individual Conifer Species

Because effects of budworm feeding on the 7 conifer species occurring in the sample stands vary with stand conditions and tree size class, this summary is in general terms.

TABLE 1

STAND CHARACTERISTICS BY CAPABILITY ZONE

Capability Zone	CZ 5	CZ 9	CZ 13	CZ 14	CZ 15	CZ 21
Number Stands in Sample	3	8	18	42	8	6
Stand Age						
Average	76	145	84	81	85	110
Youngest	70	53	42	45	50	65
Oldest	84	243	152	165	176	155
Basal Area Square Feet						
Average	198	134	116	127	132	130
Low	161	72	50	45	73	91
High	247	200	205	237	235	172
Cubic Foot Volume 1/						
Average	5100	4348	3331	4086	3839	3818
Low	4406	1734	911	974	1843	2372
High	6589	7415	8057	10658	6772	5574
Board Foot Volume 1/						
Average	22914	20491	14359	18565	18190	15227
Low	18402	6237	4634	2559	8941	5056
High	30551	37263	38666	54374	34572	23183
Annual Accretion Cubic Feet 1/						
Average	84	42	103	104	59	63
Low	59	21	38	40	19	21
High	109	72	187	227	107	100

1/ Values computed on a per-acre basis

TABLE 2

PERCENT 1/ OF WESTERN SPRUCE BUDWORM-RELATED TOP-KILL
OCCURRING TO VARIOUS SIZE CLASSES BY SPECIES AND CAPABILITY ZONE

Capability Zone	Size Class	Grand Fir			Douglas-fir			Subalpine Fir			Spruce		
		Defoliation Strata											
		1-3	4-6	7+	1-3	4-6	7+	1-3	4-6	7+	1-3	4-6	7+
5	<5"	--	--	--	--	0.0	--	--	10.3	--	--	--	--
	5-9"	--	--	--	--	0.0	--	--	0.0	--	--	--	--
	9"+	--	--	--	--	0.0	--	--	21.4	--	--	--	--
	Average	--	--	--	--	0.0	--	--	10.8	--	--	--	--
9	<5"	0.0	0.0	--	0.0	0.0	--	0.0	22.5	--	0.0	0.0	--
	5-9"	0.0	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0	--
	9"+	0.0	2.6	--	0.0	0.0	--	0.0	9.1	--	0.0	0.0	--
	Average	0.0	0.3	--	0.0	0.0	--	0.0	19.0	--	0.0	0.0	--
13	<5"	0.0	12.6	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4
	5-9"	0.0	18.2	16.7	0.0	0.0	0.0	0.0	0.0	24.3	0.0	0.0	24.2
	9"+	3.2	21.7	24.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0
	Average	0.2	14.9	13.7	0.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	19.0
14	<5"	0.0	10.5	3.0	0.0	0.0	0.0	0.0	48.3	2.9	0.0	0.0	0.0
	5-9"	0.0	13.8	16.3	0.0	0.0	8.5	0.0	0.0	26.3	0.0	0.0	0.0
	9"+	0.0	6.5	16.7	0.0	0.0	1.3	0.0	0.0	20.8	0.0	0.0	0.3
	Average	0.0	4.5	7.4	0.0	0.0	3.1	0.0	34.1	8.9	0.0	0.0	0.1
15	<5"	--	0.0	0.0	--	0.0	0.0	--	0.0	17.3	--	0.0	0.0
	5-9"	--	0.0	0.0	--	0.0	0.0	--	0.0	17.6	--	0.0	0.0
	9"+	--	0.0	28.8	--	0.0	0.0	--	0.0	31.1	--	0.0	0.0
	Average	--	0.0	12.6	--	0.0	0.0	--	0.0	21.1	--	0.0	0.0
21	<5"	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0	--	27.7
	5-9"	22.6	--	32.7	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0
	9"+	0.0	--	92.0	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0
	Average	4.2	--	11.9	0.0	--	0.0	0.0	--	0.0	0.0	--	17.1

1/ Percent of trees within each size class and defoliation strata with WSB-caused top-kill

TABLE 3

FREQUENCY AND SEVERITY OF TOP-KILL
BY TREE SPECIES AND DEFOLIATION STRATA

CZ	DEFOLIATION STRATA		GRAND FIR	DOUGLAS FIR	ALPINE FIR	SPRUCE
5	4-6	Highest % of Top-kill[1]		---	18.2	
		T.K. Stands/Sampled Stands[2]		0/3	2/3	
9	1-3	Highest % of Top-kill	---	---	---	---
		T.K. Stands/Sampled Stands	0/2	0/2	0/2	0/2
	4-6	Highest % of Top-kill	0.6	---	27.5*	---
		T.K. Stands/Sampled Stands	1/4	0/5	2/4	0/4
13	1-3	Highest % of Top-kill	0.6	---	---	---
		T.K. Stands/Sampled Stands	1/3	0/3	0/1	0/3
	4-6	Highest % of Top-kill	29.2	---	---	---
		T.K. Stands/Sampled Stands	3/7	0/6	0/2	0/2
	7+	Highest % of Top-kill	68.0	---	40.9	54.7
		T.K. Stands/Sampled Stands	5/8	0/6	2/4	1/6
14	1-3	Highest % of Top-kill	---	---	---	---
		T.K. Stands/Sampled Stands	0/11	0/11	0/2	0/5
	4-6	Highest % of Top-kill	21.9	---	---	50.0*
		T.K. Stands/Sampled Stands	4/10	0/9	0/2	1/3
	7+	Highest % of Top-kill	22.7	27.3	---	62.7*
		T.K. Stands/Sampled Stands	13/17	2/17	0/8	4/13
15	7+	Highest % of Top-kill	13.9	---	34.6	---
		T.K. Stands/Sampled Stands	1/2	0/5	3/5	0/5
21	1-3	Highest % of Top-kill	---	---	---	---
		T.K. Stands/Sampled Stands	0/3	0/3	0/3	0/3
	7+	Highest % of Top-kill	100.0	---	---	70.1*
		T.K. Stands/Sampled Stands	2/3	0/3	0/3	1/3

[1] Highest percent of top-kill observed for this species in this sample strata
[2] Number of stands with recorded top-kill for this species over the total number of sampled stands containing the tree species
* Most trees in these samples experiencing top-kill were regeneration

Grand fir, Abies grandis (Dougl.) Lindl.
Subalpine fir, Abies lasiocarpa (Hook) Nutt.

True firs are preferred hosts of feeding budworm larvae. They are often considerably defoliated within the first three years of an outbreak while adjacent, less preferred species appear untouched. In addition to defoliation, firs experience high rates of top-kill after 4 years of defoliation. Mortality was found only after 7 years of defoliation and was largely confined to small trees.

Annual radial growth for these species decreased rapidly after visible defoliation was detected and then continued to decrease at a slower rate as defoliation duration increased. Grand fir usually experienced a 20 percent reduction in annual radial growth shortly after the outbreak began and then to 30 percent after 4 to 6 years. Subalpine fir averaged about a 40 percent decline in annual radial growth over most of the outbreak

Top-kill was identified in stands defoliated for more than 3 years. Six percent and 7 percent of the grand fir and subalpine fir sampled, respectively, were top-killed.

Mortality was infrequent, being found only in stands where defoliation had occurred for more than 7 years. Mortality was usually recorded in small size class trees of both species.

Douglas-fir, Pseudotsuga menziesii (Mirb.)Franco
Engelmann spruce, Picea engelmannii Parry

Intermediate in preference, especially when occurring with the true firs, these species often escaped heavy defoliation for the first 4 to 6 years of the outbreak. During these years of defoliation top-kill did not occur, and radial growth rates were comparable to pre-defoliation growth rates for both species.

After 6 years of defoliation, top-kill was noted and radial growth rates began to decline. Both Douglas-fir and spruce experienced an annual radial growth reduction of 15 percent. Top-kill of Douglas-fir and spruce was 1 percent and 5

percent respectively.

Western larch, Larix occidentalis Nutt.

Although this deciduous conifer was defoliated by budworm larvae, it was also heavily defoliated by larch casebearer, Coleophora laricella (Hbn.), and a needle pathogen, Meria laricis Vuill. For this reason, it is unknown which pest or combination of pests may have caused the radial growth rate changes identified in Table 4.

Ponderosa pine, Pinus ponderosa Dougl.

Budworm defoliation was not observed on this species. Radial growth rate during the outbreak was determined to be near, or greater than that before the outbreak, averaging about 110 percent for all CZs. Ponderosa pine was usually a minor component of most stands, and changes in growth rates had little effect on total annual accretion of a given stand. In stands where ponderosa pine made up more than 10 percent of the basal area the increase in radial growth was not observed.

Lodgepole pine, Pinus contorta Dougl.

Defoliation by budworm was not observed on this species; however, growth rates during the outbreak were frequently 10 to 15 percent below normal in most sampled CZs. Lodgepole pine was typically a large component of sample stands, and changes in growth rate resulted in reduced volumes that should not be attributed to budworm defoliation. Values calculated are included in Table 4 totals but are not included in the net budworm effect in the discussion of each CZ.

TABLE 4

RADIAL GROWTH CHANGE, TOP-KILL, AND MORTALITY OF CONIFER SPECIES OCCURRING IN CAPABILITY ZONES AFFECTED BY WESTERN SPRUCE BUDWORM

Capability Zone	Defoliation Strata		Grand Fir	Douglas-Fir	Subalpine Fir	Spruce	Larch	Ponderosa Pine	Lodgepole Pine	Volume Totals
5		Percent of Basal Area [1]		35.0%	65.0%					
	4-6 (3 stands)	Radial growth rate [2]		92.2%	50.8%					
		Annual volume change [3]		-1.2(4.9)[7]	-23.5(17.8)					-24.7
		Percent of top-kill [4]		0.0	10.8%					
		Annual volume loss [5]		0.0	-2.1					-2.1
		Percent of mortality [4]		0.0	0.0					
		Total volume loss [6]		0.0	0.0					0.0
9		Percent of Basal Area	25.0%	29.0%	17.0%	9.0%		5.0%	15.0%	
	1-3 (2 stands)	Radial growth rate	110.0%		42.2%				91.3%	
		Annual volume change	+0.6(0.3)		-1.5(1.1)				-0.7(0.9)	-1.6
		Percent of top-kill	0.0		0.0				0.0	
		Annual volume loss	0.0		0.0				0.0	0.0
		Percent of mortality	0.0		0.0				0.0	
		Total volume loss	0.0		0.0				0.0	0.0
	4-6 (6 stands)	Radial growth rate	85.2%	85.9%	66.2%	91.5%		120.8%	103.1%	
		Annual volume change	-2.4(2.7)	-1.2(0.6)	-2.5(2.2)	-0.6(0.7)		+0.1(0.1)	+0.5(0.5)	-6.1
		Percent of top-kill	0.3%	0.0	19.0%	0.0		0.0	0.0	
		Annual volume loss	-0.3	0.0	-0.2	0.0		0.0	0.0	-0.5
		Percent of mortality	0.0	0.0	0.0	0.0		0.0	0.0	
		Total volume loss	0.0	0.0	0.0	0.0		0.0	0.0	0.0
	CZ-09 average (8 stands)	Radial growth rate	89.0%	85.9%	62.3%	91.5%		120.8%	101.9	
		Annual volume change	-1.5(1.8)	-0.9(0.5)	-2.3(1.5)	-0.4(0.5)		+0.1(0.1)	+0.1(0.4)	-5.0
		Percent of top-kill	0.1%	0.0	9.7%	0.0		0.0	0.0	
		Annual volume loss	-0.2	0.0	-0.2	0.0		0.0	0.0	-0.4
		Percent of mortality	0.0	0.0	0.0	0.0		0.0	0.0	
		Total volume loss	0.0	0.0	0.0	0.0		0.0	0.0	0.0

[1] Percent of sampled basal area
[2] Radial growth expressed as a percent of the modelled non-defoliation growth rate
[3] Estimated annual difference in volume (excluding loss due to top-kill) for defoliated and non-defoliated trees (cubic feet per acre)
[4] Percent of trees of this species experiencing budworm-caused top-kill or mortality - computed by "INDIDS"
[5] Estimated annual volume reduction associated with loss of height growth due to top-kill (cubic feet per acre) - computed by "INDIDS"
[6] Calculated volume of budworm-killed trees (cubic feet per acre) - computed by "INDIDS"
[7] Standard error of the mean for calculated volumes

* Only one sample stand

TABLE 4 cont.

RADIAL GROWTH CHANGE, TOP-KILL, AND MORTALITY OF CONIFER SPECIES OCCURRING IN CAPABILITY ZONES AFFECTED BY WESTERN SPRUCE BUDWORM

Capability Zone	Defoliation Strata		Grand Fir	Douglas-Fir	Subalpine Fir	Spruce	Larch	Ponderosa Pine	Lodgepole Pine	Volume Totals
13		Percent of Basal Area [1]	50.0%	11.0%	6.0%	15.0%	7.0%	5.0%	6.0%	
	1-3 (3 stands)	Radial growth rate [2]	105.7%	106.2%		*89.0%			*43.8%	
		Annual volume change [3]	+10.7(18.0)[7]	+1.8(0.9)		-1.1(1.1)			-4.0(4.0)	+7.4
		Percent of Top-kill [4]	0.2%	0.0		0.0			0.0	
		Annual volume loss [5]	-0.3	0.0		0.0			0.0	-0.3
		Percent of mortality [4]	0.0	0.0		0.0			0.0	
		Total volume loss [6]	0.0	0.0		0.0			0.0	0.0
	4-6 (7 stands)	Radial growth rate	78.8%	86.4%		105.4%	*129.2%	*97.9%		
		Annual volume change	-9.3(2.5)	+0.5(0.9)		+0.2(0.3)	+0.3(0.3)	+0.6(0.6)		-7.7
		Percent of top-kill	14.9%	0.0		0.0	0.0	0.0		
		Annual volume loss	2.1	0.0		0.0	0.0	0.0		-2.1
		Percent of mortality	0.0	0.0		0.0	0.0	0.0		
		Total volume loss	0.0	0.0		0.0	0.0	0.0		0.0
	7+ (8 stands)	Radial growth rate	58.9%	*124.7	51.2%	70.0%	120.3%	*58.6%	*122.2%	
		Annual volume change	-23.6(11.4)	+0.2(0.5)	-3.5(2.3)	-4.6(3.2)	+0.8(0.8)	-1.4(1.1)	+0.1(0.1)	-32.0
		Percent of top-kill	13.7%	0.0	9.5%	19.0%	0.0	0.0	0.0	
		Annual volume loss	2.3	0.0	1.3	0.8	0.0	0.0	0.0	-4.4
		Percent of mortality	4.4%	0.0	35.8%	0.0	0.0	0.0	0.0	
		Total volume loss	0.0	0.0	40.4	0.0	0.0	0.0	0.0	-40.4
	CZ-13 average (18 stands)	Radial growth rate	74.3%	105.0%	51.2%	87.6%	122.4%	88.9%	90.6	
		Annual volume change	-13.6(6.7)	+0.8(0.4)	-1.8(1.2)	-2.4(1.7)	+0.5(0.4)	-0.5(0.6)	-1.9(1.4)	-19.2
		Percent of top-kill	7.7%	0.0	8.8%	11.6%	0.0	0.0	0.0	
		Annual Volume loss	1.9	0.0	0.6	0.4	0.0	0.0	0.0	-2.9
		Percent of mortality	1.4%	0.0	33.5%	0.0	0.0	0.0	0.0	
		Total volume loss	0.0	0.0	17.9	0.0	0.0	0.0	0.0	-17.9

[1] Percent of sampled basal area
[2] Radial growth expressed as a percent of the modelled non-defoliation growth rate
[3] Estimated annual difference in volume (excluding loss due to top-kill) for defoliated and non-defoliated trees (cubic feet per acre)
[4] Percent of trees of this species experiencing budworm-caused top-kill or mortality - computed by "INDIDS"
[5] Estimated annual volume reduction associated with loss of height growth due to top-kill (cubic feet per acre) - computed by "INDIDS"
[6] Calculated volume of budworm-killed trees (cubic feet per acre) - computed by "INDIDS"
[7] Standard error of the mean for calculated volumes

* Only one sample stand

TABLE 4 cont.

RADIAL GROWTH CHANGE, TOP-KILL, AND MORTALITY
OF CONIFER SPECIES OCCURRING IN CAPABILITY ZONES
AFFECTED BY WESTERN SPRUCE BUDWORM

Capability Zone	Defoliation Strata		Grand Fir	Douglas-Fir	Subalpine Fir	Spruce	Larch	Ponderosa Pine	Lodgepole Pine	Volume Totals
14		Percent of Basal Area [1]	47.0%	25.0%	2.0%	11.0%	2.0%	7.0%	5.0%	
		Radial growth rate [2]	76.5%	93.3%	*52.4%	95.0%		122.5%	*34.4%	
		Annual volume chance [3]	-19.5(8.2)[7]	-0.4(3.7)	0.0(0.0)	+0.6(0.8)		+1.7(1.4)	-0.1(0.1)	-17.7
	1-3 (12 stands)	Percent of top-kill [4]	0.0	0.0	0.0	0.0		0.0	0.0	
		Annual volume loss [5]	0.0	0.0	0.0	0.0		0.0	0.0	0.0
		Percent of mortality [4]	0.0	0.0	0.0	0.0		0.0	0.0	
		Total volume loss [6]	0.0	0.0	0.0	0.0		0.0	0.0	0.0
		Radial growth rate	77.7%	96.3%	*61.8%	96.6%		116.9%	91.1%	
		Annual volume change	-18.0(5.3)	-0.6(1.2)	0.0(0.0)	-0.4(0.6)		+0.4(0.4)	+0.3(0.2)	-18.3
	4-6 (11 stands)	Percent of top-kill	4.5%	0.0	34.1%	0.0		0.0	0.0	
		Annual volume loss	-1.0	0.0	0.0	0.0		0.0	0.0	-1.0
		Percent of mortality	0.0	0.0	0.0	0.0		0.0	0.0	
		Total volume loss	0.0	0.0	0.0	0.0		0.0	0.0	0.0
		Radial growth rate	71.5%	79.0%	*108.7%	90.0%	70.9%	104.6%	*63.7	
		Annual volume change	-20.0(4.5)	-4.0(2.1)	+0.3(0.3)	-0.9(0.6)	-0.2(0.4)	-0.1(0.8)	0.0(0.0)	-24.8
	7+ (19 stands)	Percent of top-kill	7.4%	3.1%	8.9%	0.1%	0.0	0.0	0.0	
		Annual volume loss	-4.5	-0.2	-0.6	-0.04	0.0	0.0	0.0	-5.3
		Percent of mortality	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Total volume loss	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Radial growth rate	74.8%	85.4%	83.8%	91.7%	70.9%	109.3%	84.2	
		Annual volume change	-19.4(3.2)	-2.1(1.4)	+0.2(0.2)	-0.4(0.4)	-0.1(0.1)	+0.5(0.5)	+0.1(0.1)	-21.2
	CZ-14 average (42 stands)	Percent of top-kill	3.7%	0.5%	13.6%	<0.1%	0.0	0.0	0.0	
		Annual volume loss	-2.3	-0.1	-0.3	-0.02	0.0	0.0	0.0	-2.7
		Percent of mortality	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Total volume loss	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[1] Percent of sampled basal area
[2] Radial growth expressed as a percent of the modelled non-defoliation growth rate
[3] Estimated annual difference in volume (excluding loss due to top-kill) for defoliated and non-defoliated trees (cubic feet per acre)
[4] Percent of trees of this species experiencing budworm-caused top-kill or mortality - computed by "INDIDS"
[5] Estimated annual volume reduction associated with loss of height growth due to top-kill (cubic feet per acre) - computed by "INDIDS"
[6] Calculated volume of budworm-killed trees (cubic feet per acre) - computed by "INDIDS"
[7] Standard error of the mean for calculated volumes

* Only one sample stand

TABLE 4 cont.

RADIAL GROWTH CHANGE, TOP-KILL, AND MORTALITY OF CONIFER SPECIES OCCURRING IN CAPABILITY ZONES AFFECTED BY WESTERN SPRUCE BUDWORM

Capability Zone	Defoliation Strata		Grand Fir	Douglas Fir	Subalpine Fir	Spruce	Larch	Ponderosa Pine	Lodgepole Pine	Volume Totals
15		Percent of Basal Area [1]	21.0%	13.0%	40.0%	10.0%	2.0%	1.0%	12.0%	
	7+ (8 stands)	Radial growth rate [2]	53.2%	76.5%	70.3%	88.1%	64.2%	123.1%	84.4%	
		Annual volume change [3]	-13.6(7.9)[7]	-0.6(0.7)	-9.4(4.6)	+0.4(0.6)	-0.2(0.2)	0.0(0.0)	-0.5(0.4)	-23.9
		Percent of top-kill [4]	12.6	0.0	21.1	0.0	0.0	0.0	0.0	
		Annual volume loss [5]	-0.3	0.0	-1.8	0.0	0.0	0.0	0.0	-2.1
		Percent of mortality [4]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Total volume loss [6]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21		Percent of Basal Area	14.0%	32.0%	13.0%	10.0%	5.0%	5.0%	21.0%	
	1-3 (3 stands)	Radial growth rate	*91.9%	62.9%	44.2%			96.1%	*54.4%	
		Annual volume change	-0.8(0.5)	-9.3(6.0)	-3.1(2.3)			-0.8(0.6)	-4.2(4.3)	-18.2
		Percent of top-kill	4.2%	0.0	0.0			0.0	0.0	
		Annual volume loss	0.0	0.0	0.0			0.0	0.0	0.0
		Percent of mortality	0.0	0.0	0.0			0.0	0.0	
		Total volume loss	0.0	0.0	0.0			0.0	0.0	0.0
	7+ (3 stands)	Radial growth rate	*53.8%	78.5%	70.4%	68.2%	93.5%		72.6%	
		Annual volume change	-10.3(10.4)	-2.4(2.8)	-1.2(1.3)	-5.2(1.7)	+0.9(1.0)		-4.2(4.2)	-22.4
		Percent of top-kill	11.9%	0.0	0.0	17.1%	0.0		0.0	
		Annual volume loss	-3.0	0.0	0.0	0.0	0.0		0.0	-3.0
		Percent of mortality	0.0	0.0	20.0%	0.0	0.0		0.0	
		Total volume loss	0.0	0.0	-190.0	0.0	0.0		0.0	-190.0
	CZ-21 average (6 stands)	Radial growth rate	66.9%	71.5%	52.5%	68.2%	93.5%	96.1%	63.3%	
		Annual volume change	-5.6(5.1)	-5.9(3.3)	-2.1(1.3)	-2.6(1.4)	+0.6(0.5)	-0.4(0.3)	-4.2(2.7)	-20.2
		Percent of top-kill	8.3%	0.0	0.0	11.2%	0.0	0.0	0.0	
		Annual volume loss	-1.5	0.0	0.0	0.0	0.0	0.0	0.0	-1.5
		Percent of mortality	0.0	0.0	8.8%	0.0	0.0	0.0	0.0	
		Total volume loss	0.0	0.0	-95.0	0.0	0.0	0.0	0.0	-95.0

[1] Percent of sampled basal area
[2] Radial growth expressed as a percent of the modelled non-defoliation growth rate
[3] Estimated annual difference in volume (excluding loss due to top-kill) for defoliated and non-defoliated trees (cubic feet per acre)
[4] Percent of trees of this species experiencing budworm-caused top-kill or mortality - computed by "INDIDS"
[5] Estimated annual volume reduction associated with loss of height growth due to top-kill (cubic feet per acre)
[6] Calculated volume of budworm-killed trees (cubic feet per acre) - computed by "INDIDS"
[7] Standard error of the mean for calculated volumes

* Only one sample stand

Effects of Defoliation in Each Capability Zone

General effects of budworm feeding for each capability zone are summarized below and, unless otherwise specified, are averages of all stands sampled in the capability zone specified. Data presented is extracted largely from Table 4.

Capability Zone 5 - Boise Ridge.

Capability zone 5 was of low sampling priority because grand fir is not a major species in the area and defoliation has not yet reached the severity of other zones. Thus, only 3 stands were sampled, all from the 4-6 year defoliation stratum. Sampled stands consisted of Douglas-fir and subalpine fir with an average 6 years of defoliation.

Subalpine fir, comprising 65 percent of the basal area, was the largest stand component. Average annual radial growth increment, when compared to pre-defoliation growth, was determined to have been reduced by 49.2 percent. This amounted to an estimated annual volume reduction of 23.5 ft^3/A over the 6 years of defoliation. Top-kill occurred on 10.8 percent of the trees, resulting in an annual volume loss of 2.1 ft^3/A. Tree mortality related to budworm activity was not observed.

Douglas-fir incurred only minor damage from budworm feeding. Average annual radial growth was reduced by 7.8 percent with an associated volume reduction of 1.2 $ft^3/A/yr$ over the defoliated period. Top-kill and mortality related to budworm activity were not observed.

Capability Zone 9 - Scott Mountain - Gold Fork.

The 8 sample stands in this zone consisted of a mixture of all tree species previously listed except western larch. Grand fir and Douglas-fir comprised 55 percent of the basal area. Stands in the 1-3 and 4-6 year defoliation strata were sampled with the average stand being defoliated for an average of 5 years. The average annual accretion without defoliation was calculated to be

42 ft^3/A/yr, the lowest of any sampled CZ.

Subalpine fir was the most severely affected of all species with annual radial growth being reduced by 38 percent. Top-kill was detected on 9.7 percent of all sampled trees. Associated volume reductions were 2.3 and 0.2 ft^3/A/yr for radial increment and height growth reductions, respectively. Budworm-caused mortality was not observed.

Average annual radial growth reduction for grand fir was 11 percent which amounts to a volume reduction of 1.5 ft^3/A/yr. Top-killing occurred on 0.1 percent of the trees, but no budworm-caused mortality was observed.

Radial growth of Douglas-fir and spruce was reduced by an estimated 14.1 percent and 8.5 percent respectively with an average volume reduction of 0.9 and 0.4 ft^3/A/yr, respectively. Budworm-caused top-kill or mortality was not observed.

Calculated growth rates of ponderosa and lodgepole pine during the defoliation period were increased by 20.8 percent and 1.9 percent, respectively, over pre-defoliation growth. Associated volume increases were very low, however due to the low basal area of these species in the sample. No budworm defoliation was observed on either species.

The net effect of budworm feeding in CZ-9, excluding those effects on western larch and lodgepole pine, is an average volume reduction of 5.5 ft^3/A/yr for the first 6 years of defoliation.

Capability Zone 13 - Third Fork on Boise and most of Weiser - Little Salmon River Drainages on Payette.

All conifer species previously listed were present to some degree in the 18 sample stands. Grand fir was the major component, comprising 50 percent of the basal area. All defoliation strata were sampled with these stands averaging 9 years of defoliation.

Subalpine fir was impacted more than other species by budworm defoliation, but due to the small amount of subalpine fir in the sample (6 percent), total associated volume reductions were minor. Radial growth with budworm was reduced by 48.8 percent, and top-kill was observed on 8.8 percent of the trees. Annual volume reductions were only 1.8 and 0.6 ft^3/A/yr for radial growth and top-kill, respectively, over the 9 years of defoliation. Of the subalpine fir sampled; 33.5 percent were dead. This represents a total volume loss of 17.9 ft^3/A or 2.0 ft^3/A/yr averaged over the 9 year defoliation period.

Grand fir experienced an average radial growth reduction of 25.7 percent. This amounts to a 13.6 ft^3/A/yr volume reduction over the defoliation period. Top-kill was observed on 7.7 percent of the grand fir sampled. The associated volume reduction is estimated to be 1.9 ft^3/A/yr. Budworm feeding resulted in mortality of 1.4 percent of the grand fir. Associated volume loss was not calculated because all affected trees were seedlings.

Radial growth of spruce was reduced by 12.4 during defoliation and amounted to volume loss of 2.4 ft^3/A/yr. While 11.6 percent of the spruce sampled was top-killed, most were seedlings and volume loss was negligible. No budworm caused mortality was observed.

Effect of budworm feeding on radial growth rates of Douglas-fir, ponderosa pine, and lodgepole pine was minimal. No budworm caused top-kill or mortality was detected on any of these species.

The net effect of budworm activity in this unit excluding questionable effects on western larch and lodgepole pine, is an average growth reduction of 22.7 ft^3/A/yr.

Capability Zone 14 - Sagehen and Midelevation slopes of North Fork of Payette River (Boise and Payette NF's).

Budworm impact data were collected from 42 stands. Tree species composition for the sample stands was similar to that of CZ-13 with grand fir being the predominant species. Sampled stands averaged 7 years of defoliation at the

time of this survey.

Grand fir exhibited a radial growth reduction averaging 25.2 percent. This amounted to a volume of 19.4 ft^3/yr. Top-kill resulting from budworm defoliation was observed on 3.7 percent of the sample trees resulting in an annual volume reduction of 2.3 ft^3/A. No budworm-caused mortality was observed.

Subalpine fir experienced a radial growth reduction of 16.2 percent and top-kill of 13.6 percent, but total volume loss was negligible due to the small amount (2 percent) of subalpine fir in the sample. Budworm caused mortality was not observed.

Radial growth for Douglas-fir was reduced by 14.6 percent resulting in an estimated volume reduction of 2.1 ft^3/A/yr. Top-kill was observed on 3.1 percent of the Douglas-fir occurring on stands being defoliated for more than 7 years. This represents only 0.5 percent of the sampled Douglas-fir, and amounts to a very small volume loss. No budworm-caused mortality was recorded on sampled Douglas-fir.

Spruce, ponderosa pine, and lodgepole pine experienced small decreases or increases in radial growth. Top-kill was observed on 0.1 percent of sampled spruce. Budworm related mortality was not observed.

In CZ-14 the net effect of budworm defoliation, excluding effects on western larch and lodgepole pine is an average annual growth reduction of 23.9 ft^3/A/yr.

Capability Zone 15 - West Mountain.

All 7 conifer species were represented in the 8 stands sampled. Subalpine fir was the most common species, comprising 40 percent of the basal area. All sample stands were selected from 7+ defoliation stratum, and averaged 8 years of defoliation.

Subalpine fir radial growth decreased by 29.7 percent during defoliation, with an associated volume reduction of 9.4 ft^3/A/yr. Top-kill caused by budworm feeding was observed on 21.1 percent of the sample trees and resulted in a 1.8 ft^3/A/yr volume reduction. No budworm-related mortality was observed.

Although radial growth of Douglas-fir, spruce, ponderosa pine, and lodgepole pine was increased or decreased by as much as 25 percent of pre-defoliation growth, changes in volume were negligible. No budworm-caused top-kill or mortality was observed for any of these species.

The net effect of budworm activity in CZ-15, excluding effects on western larch and lodgepole pine, is an average annual growth reduction of 25.3 ft^3/A/yr for stands being defoliated for 7 or more years.

Capability Zone 21 - Dollar Creek and along South Fork of Salmon River.

Douglas-fir and lodgepole pine, which comprised 32 and 21 percent of the basal area, respectively, were the predominant species in the 6 stands sampled. Stands in two defoliation strata, 1-3 and 7+ were sampled, and averaged 7 years of defoliation.

Average annual radial growth of Douglas-fir was reduced by 28.5 percent. The associated volume reduction was 5.9 ft^3/A/yr. No top-kill or mortality attributed to budworm defoliation was observed.

Radial growth reduction of subalpine fir was 47.5 percent, which amounts to a volume reduction of 2.1 ft^3/A/yr. However, 8.8 percent of the sample trees appeared to have been killed by budworm defoliation. This mortality represents a total loss of 95 ft^3/A or 14.7 ft^3/A/yr annual volume loss.

Grand fir and spruce were affected by defoliation to about the same extent: radial growth was reduced by about 23 percent for each species with volume reductions of 5.6 and 2.1 ft^3/A/yr for grand fir and spruce respectively. Top-kill was observed on 8.3 percent of the grand fir and 11.2 percent of the spruce. No budworm-caused mortality was observed.

Lodgepole pine experienced an average radial growth reduction of 36.7 percent resulting in a volume reduction of 4.2 ft^3/A/yr.

Ponderosa pine was not affected by budworm defoliation.

The net effect of budworm activity, excluding effects on western larch and lodgepole pine, was an average volume reduction of 32.3 ft^3/A/yr.

DISCUSSION

Previous growth loss estimates for budworm feeding (Beveridge 1978) were based on growth loss associated with mortality and top-killed trees. Although for these evaluations similar methods were used to calculate volume loss due to top-kill, radial growth loss not associated with top-kill and radial growth of nonhosts were also estimated. Thus, not only are top-kill and mortality considered, but effects on radial growth of hosts and associated nonhosts are considered, providing a significant improvement in assessing effects of budworm activity.

Radial growth effects were calculated by comparing radial growth with and without defoliation for extended periods of time, and are presented as an average annual change in growth. Although these average values are accurate representations over entire periods of time, it should be noted that the rate of growth reduction varies throughout the defoliation period, depending upon defoliation intensity, host species, and stand composition. Typically, radial growth reduction is low initially, then increases as the period of defoliation increases.

Often, to determine effects of pests, growth of nonhost species or of unaffected hosts growing in different areas are compared with growth of affected hosts during comparable time periods. This method has obvious shortcomings including the inability to consider differential climatic effects on various conifer species or the effects of other pests on nonhosts. Because of these drawbacks, a separate computer program utilizing equations from the stand prognosis model, was used to reconstruct (backdate) sample trees to

pre-defoliation characteristics, then the stand prognosis model was used to project them, with and without defoliation, to the sample date using site-specific growth rates and other localized factors.

When radial growth rates were calculated and defoliation growth compared to growth without budworm, host species were expected to show some degree of growth reduction, and nonhost species were expected to remain near pre-defoliation levels. Generally, the preferred host species responded as expected. However nonhost species did not always react as anticipated. While growth of ponderosa pine increased slightly, growth of most lodgepole pine decreased sharply.

Ponderosa pine generally experienced an increase in radial growth during periods of budworm activity. Possible explanations for this are increased precipitation during the defoliation period or reduced competition from host trees defoliated by budworm.

To assess precipitation effects, annual and summer precipitation in the study area for the last two decades was examined. Although above normal summer precipitation was noted during the last two years, 1980 and 1981, summer precipitation from 1976 through 1979 was below normal. Over the last 20 years there does not appear to be any extended period of time with higher or lower moisture than any other, suggesting that precipitation is not the major factor involved.

A more likley explanation for the responce by ponderosa pine may be due to reduced competition, and perhaps nutrient recycling resulting from frass deposition. In sample stands where less than 10 percent of the basal area was composed of nonhost species, ponderosa pine usually experienced growth rates higher than pre-defoliation or normal growth rates. In sample stands where the nonhost component exceeded 20 percent, ponderosa pine usually grew at rates near or slightly below stand pre-defoliation level. While the sample size is small, these data suggest that ponderosa pine may respond to reduced competition. If this is correct, a host to nonhost threshold ratio of approximately 9:1 must occur before ponderosa pine will benefit from western budworm feeding on hosts.

Species composition also appears to affect amount of growth reduction on defoliated hosts. Amount of annual growth reduction during any defoliation period was generally greatest for true firs in relatively pure stands. Smallest effects of budworm feeding on true firs were noted where nonhosts were well represented in sample stands. Where nonhosts comprised over 25 percent of the stand, host species experienced much less growth reduction than they did when occurring with few nonhosts. Again, the sample size was small, but this trend was evident.

Radial growth rates for lodgepole pine were typically 10 to 15 percent lower during the defoliation period than they were prior to it. Most sampled lodgepole pines were overmature, and they may have been declining in growth, which would be reflected in the comparison of the two consecutive periods of radial increment growth done in this study.

Although results of this survey provide information not available from previous surveys, many areas remain unsampled, and budworm defoliation effects are still not fully evaluated. However, very complete data were gathered for CZ-14, and it may be possible to estimate growth rate changes and other budworm defoliation effects for non-sample areas using values and trends identified in this CZ. If these estimates are extrapolated to other areas,it must be done with caution since much more information is needed to know exactly how defoliation effects vary due to species composition, habitat type, and management practices.

While data presented here are significantly improved compared to previous budworm-impact estimates, further refinements are necessary to (1) more fully evaluate effects throughout crowns of individual trees in specific environments, (2) identify outbreak duration and frequency on specific sites and across large areas, and (3) evaluate long-term effects of budworm feeding on the ecosystems in question.

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APPENDIX A

FORPLAN ZONE 5 NAME BOISE RIDGE

Location and Coverage

This zone covers the north-south trending Boise Ridge. It extends from Kearney Lakes on the south to Hawley Mountain on the north. It includes the mid and upper portions of many small watersheds draining to the lower Payette River and Grimes Creek.

Geomorphic and Topographic Characteristics

The Boise ridge is a north-south trending, major faulted ridge system in granitic bedrock. Major ridgetops are somewhat rounded, but slopes are moderately to strongly dissected. Slope gradients are moderately steep to steep. Bedrock is well weathered. Elevations range from 4,000 to 7,000 feet.

Climate

Mean annual precipitation is 25-35 inches. Snowpack is moderate to heavy and persists through the winter except on lower elevation south slopes. Contrasting aspects have significantly differing microclimates.

Soils

Soils are shallow to deep, young, coarse textured stony and nonstony. Depth of soils varies with landscape position. Parent material is weathered granitic bedrock. Some ridgetops have rock outcrops.

Vegetation

Moderate to dense forest stands in the Douglas-fir series occur on gentle and sheltered terrain. Understory varies from dense shrubs to grass. Ridgetops and southerly slopes have light to moderate density forest cover in ponderosa pine and Douglas-fir series habitat types.

Hydrology

Major runoff is in April and May from snowmelt. Subsurface flow is heavy at that time. Water yield 5-15 inches.

FORPLAN ZONE 9 NAME SCOTT MOUNTAIN - GOLD FORK

Location and Coverage

This zone includes seven different units extending from Thorn Creek Butte to The Needles. Major units are around Pilot Peak, Scott Mountain, East Mountain, Stony Meadows, Tripod Peak, and The Needles. These are the high elevation lands of the central and northwestern portion of the Forest.

Geomorphic and Topographic Characteristics

Elevations are predominantly above 6,500 feet. Bedrock is moderately weathered to unweathered granitics. These are glaciated and cryic lands. Bedrock fracturing and soil depth vary with glacier scouring pattern. Cryic slopes are rounded with moderate to moderately steep gradients. U-shaped valleys are present on most large stream headwaters. Rocky ridges and cirque basins exist on the glaciated terrain. Gradients in glaciated terrain are steep.

Climate

Mean annual precipitation is 35-65 inches. Snowpack persists from November through May. Summers are cool and winters extremely cold. Growing season is very short.

Soils

On cryic lands, soils are shallow and moderately deep, weakly developed, coarse textured, and cobbly. On glaciated lands, soils are extremely variable--shallow, young, stony, and coarse textured on scoured areas to deep, young, stony, coarse textured on toe slopes, valley bottoms, and basins.

Vegetation

Severely scoured lands have limited forest cover and considerable exposed rock. Other areas have moderate to dense forest cover in subalpine fir series. Lodgepole pine is a common seral species. Open stands of trees with grass understory is present on many south slopes.

Hydrology

Mean annual water yield is 20-40 inches. This large water yield comes from snowmelt in May and June. Much surface runoff occurs in the many drainageways present. Basins and valley bottoms have high water tables during spring and early summer. Avalanches are common in glaciated terrain.

FORPLAN 13 NAME THIRD FORK

Location and Coverage

This zone covers the basalt lands along the extreme western edge of the Forest. These lands are in the Squaw Creek drainage.

Geomorphic and Topographic Characteristics

Elevation range is 4,000 to 5,500 feet. These lands are in block faulted basalt bedrock and include scarp slopes and dip slopes. The west facing dip slopes are moderately steep and long. The east facing scarp slopes are steep and short. Main ridges are broadly rounded. Scarp slopes are sometimes well dissected by drainageways and spur ridges. Relief is moderate.

Climate

Mean annual precipitation is 25-30 inches. Snowpack is light to moderate and persists through the winter on northerly aspects and higher elevations. Southerly aspects have intermittent snowpack.

Soils

Shallow to moderately deep clay loam soils with some profile development are dominant. Cobble material is common. Dip slope soils average a shallower depth than scarp slope soils. Scabland areas exist on some dip slopes.

Vegetation

Intermixed forest and sagebrush grass predominates. Northerly slopes and higher areas support dense forest in the Douglas-fir habitat types. Exposed and shallow soiled sites support sagebrush-grass habitat types. Riparian strips of deciduous shrubs and trees follow perennial and ephemeral streams.

Hydrology

Dip slopes are less permeable and produce more rapid runoff than scarp slopes. Basalt flow interfaces are often aquifers for subsurface runoff. This flow often comes to the surface where the interfaces have been exposed by downcutting of streams. Mean annual water yield is 5-10 inches.

FORPLAN ZONE 14 NAME SAGEHEN

Location and Coverage

This zone covers four major units: (1) Squaw Creek midelevation areas, (2) non-glaciated slopes of West Mountain, (3) midelevation slopes of the Scriver Creek area between the North and Middle Forks of the Payette River, and (4) midelevation slopes of Gold Fork River, Big Creek, and Clear Creek east of Cascade.

Geomorphic and Topographic Characteristics

Elevation range is 4,000 to 6,500 feet. The Squaw Creek and Scriver Creek areas are moderately dissected, moderate gradient fluvial slopes in well weathered granitics, influenced by basalts. The West Mountain area has moderately steep to steep, moderately dissected granitic slopes with basalt influence. The Gold Fork-Big Creek-Clear Creek unit has moderately steep to steep, moderately dissected granitic slopes with no basalt influence. Relief is variable from low on the Squaw Creek area to high on the Big Creek and West Mountain areas.

Climate

Mean annual precipitation is 25-40 inches. Temperatures are moderate. Snowpacks are moderately deep and persist through the winter. Moist spring weather is common.

Soils

The Sagehen, Scriver Creek, and West Mountain areas have moderately deep, young, medium to coarse textured soils with few rock outcrops. The Big Creek-Clear Creek-Gold Fork area has shallow to moderately deep, young, coarse textured soils with occasional rock outcrops.

Vegetation

Moderate to dense forest cover predominates. Habitat types are in the Douglas-fir and grand fir series. Subalpine fir habitat types exist on upper fringes and in cold pockets. Engelman spruce is present on very moist sites.

Hydrology

Mean annual water yield is 10-20 inches. Snowpacks melt in April and May with runoff from slopes mainly as subsurface flow and deep seepage.

FORPLAN ZONE 15 NAME WEST MOUNTAIN

Location and Coverage

This zone includes the east facing, upper slopes of West Mountain from Tripod Peak to No Business Mountain.

Geomorphic and Topographic Characteristics

Elevations range from 6,500 to 8,300 feet. These are glaciated upper slopes with cirque basins and short U-shaped valleys on a scarp slope of a block faulted mountain range. Predominant aspect of the scarp slope is easterly. Hard basement rock is granitic and has been exposed in most areas. However, remnants of basalt flows exist in many areas. Slopes are steep, especially in cirque headlands.

Climate

Mean annual precipitation is 35-50 inches. Snowpacks are deep and persist into June. Growing season is very short.

Soils

Soils are shallow to deep, young, stony, medium to coarse texture. Depth varies with thickness of glacial deposits or colluvial materials. Exposed rock is common on cirque headwalls and thresholds.

Vegetation

U-shaped valley bottoms and lower slopes are forested with dense stands of the subalpine fir series. Upper slopes and headwalls are mountain brush or grass covered with scattered tree overstorage.

Hydrology

Mean annual water yield is 20-30 inches. All drainageways carry heavy flows during high snowmelt periods in May and early June. Basins and valley bottom deposits accumulate runoff and exhibit high water tables in spring and release water into summer.

FORPLAN ZONE 21 NAME DOLLAR CREEK

Location and Coverage

This zone covers the fluvial slopes along the South Fork Salmon River from Yellow-jacket Creek to Goat Creek.

Geomorphic and Topographic Characteristics

Elevations range from 5,000 to 6,500 feet. These lands are predominantly moderately dissected, moderately steep to steep fluvial granitic slopes. Bedrock is generally well weathered. Relief is moderate to high. Ridges are subrounded and drainages are moderately V-shaped.

Climate

Mean annual precipitation is 30-40 inches. Temperatures are cool. Snowpack is moderate and persists into May. Moist spring weather is common.

Soils

Soils are shallow and moderately deep, young, sandy, and moderately coarse textured with or without gravel and stones. Areas of large rock outcrop exist in the cougar rock area.

Vegetation

The area is predominantly forested with moderately dense to dense stands of Douglas-fir and ponderosa pine on east and south slopes and subalpine fir types on northerly slopes. Western larch, Engelman spruce, and lodgepole pine are common species.

Hydrology

Mean annual water yield is 10-20 inches. Snowmelt in April and May produces heavy subsurface flow.